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THE FATE OF THE BARBS OF GUMARA RIVER, ETHIOPIA

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ABSTRACT: The barbs (*Barbus spp., Cyprinidae, Teleostei*) of Gumara River, Lake Tana, Ethiopia, have become the point of interest for today's researchers and fishermen. The presence of almost 100% reproductively ripe (mature) fish upstream and the highest standardized catch per unit of effort for gillnets during July to September proves their seasonal spawning migration. The Gumara barb market records made in Woreta town, that cover about 75% of the river's one side total seasonal catch, indicate that the catch level has decreased tremendously within four years: from 19.0 tons in 1995 to 2.2 tons in 1998. The accompanying total number of scoop nets (the most common fishing gear used on Gumara River) rose from year to year: 169 nets in 1995, 204 nets in 1996, 409 nets in 1997 and 700 nets in 1998. The average weight of the commercial catches has decreased almost by half within a period of three years: from 923g in 1995 to 481g in 1998. Catch per Unit Effort (CpUE) estimates made for the traditional fishing gear used (scoop net, fish trap and line and hook), however, did not show sharp declines. These findings show that the barbs of Gumara River could be in danger and appropriate management measures should be taken in time, most preferably closed fishing area together with fishing gear restrictions during the main rainy season.

Key words/phrases: Average size, *Barbus spp.*, catch per unit of effort, Gumara River, spawning

INTRODUCTION

Lake Tana is Ethiopia's largest lake found in the northwestern highlands of the country constituting about half the size of the freshwater bodies of the nation. It is found at 1800 m above sea level. It has a surface area of about 3200km^2, maximum and average depths of about 14 and 8m, respectively. It has many in-flowing rivers, but has only a single outflow, that is the Blue Nile (Amharic: *'Tukur Abbay'*) (Fig. 1).

Lake Tana's major in-flowing perennial rivers are Gelgel Abbay in the west, Megech, Dirma and Arno-Garno in the north, and Reb, Gumara and Gelda in the east. Of these, Gumara River is the one that is considered for aspects of

fisheries, commercial as well as research and monitoring activities. The fact that it serves as a major seasonal spawning ground for the world's unique *Barbus* species flock has attracted the attention of researchers and artisanal fishermen.

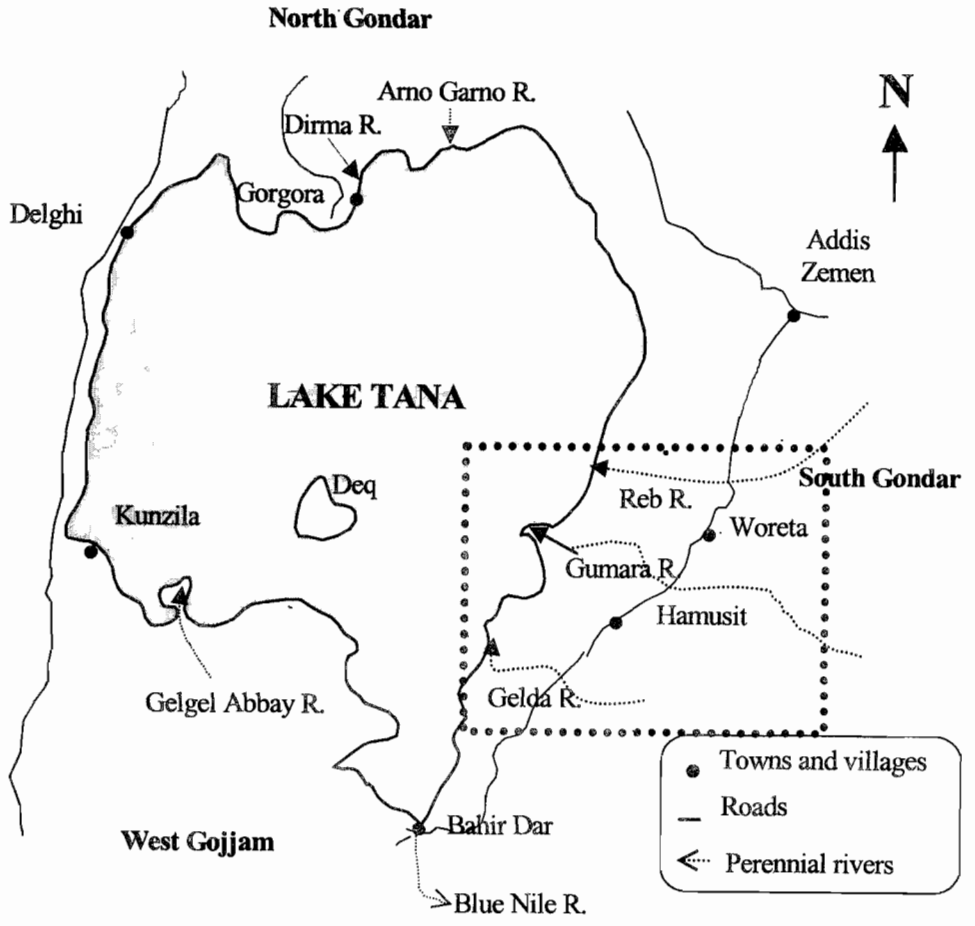

Fig. 1. Schematic map of Lake Tana showing the study area (Gumara River) surrounded in a rectangle of broken lines.

The fish species of Lake Tana are large barbs (*Barbus spp.*), catfish (*Clarias gariepinus* Burchell 1822), tilapia (*Oreochromis niloticus* Linnaeus 1766), bezo (*Varicorhinus beso* Rüppell 1836), small barbs (*Barbus spp.*), *Garra spp.* and *Nemachilus abyssinicus* Boulenger 1902. The first four are big fish (usually greater than 15 cm adult size) and hence commercially important species. The other three are small fish of less than 15 cm adult size and serve as feed for the larger piscivore fish and birds.

What makes Lake Tana interesting is that the large barbs (*Barbus spp.*) seem to make up a unique "species flock". As Nagelkerke *et al.* (1995a) puts it, several distinct *Barbus* species exist in Lake Tana, of which eight are found to be piscivores, a case not so common in cyprinids that lack teeth in their oral jaws and are without stomach. However, another group of researchers does not accept this idea, and limits the difference observed in Lake Tana barbs to only morphological plasticity (Dgebuadze *et al.*, 1999). Here we treated Lake Tana barbs as barbs only and not as different species because, first, at the time when these data were collected, these fish were not described as different species. Secondly, no matter what the results of evolutionary and systematics studies be, currently the traditional riverine as well as the lake's motorized-boat fishermen are exploiting these fish without any selection made to the species. That is they tend to catch relatively big marketable fish. The very rare presence of the Ethiopian endemic *N. abyssinicus* in Lake Tana [the first specimen was described in 1902 (as cited in Boulenger, 1911), the second in 1993 (as cited in Nagelkerke, 1997) and the last three in August 2000 (personal observation)] is also another interesting phenomenon.

Lake Tana's total annual catch (including Gumara River) seems very low when compared to that of other smaller lakes in the country. So far, there are different estimates of Lake Tana's potential in fish production. However, all these estimates seem to have used more general and holistic models due to the absence of good total annual catch and effort records. The values of the estimates made so far range from 13,000 to more than 20,000 tons/year. The most important matter here is that we need to update these old estimates based on the more reliable analytical models. The maximum total annual catch estimated so far was 1470 tons in 1996/97, which, however, has declined from then on (to 799 tons in 1998/99) (Fig. 2). The total annual catch estimates made from 1996/97 to 1997/98 depict that *Barbus spp.* constitutes almost half of the species composition (Fig. 3). About two-thirds of the annual catch was contributed by the reed (papyrus) boat fishery (Fig. 4), a case common in other African lakes such as Lake Victoria where artisanal fishery is more important than the industrial one (Witte and van Densen, 1995).

Different fishing techniques are implemented in Lake Tana and its rivers. These include local gill nets (made of plastic rope), modern gill nets (nylon twines), scoop net (with or without fencing the river wholly or partially), cast net, fish trap, spear (in the flood plains around the lake), and the age-old fish poisoning with the plant *Milletia ferruginea* (Amharic: *'Birbira'*). The fishing rafts used on the lake along with these gear are the traditional papyrus rafts and the motorized (and some manually poled) wooden and steel boats.

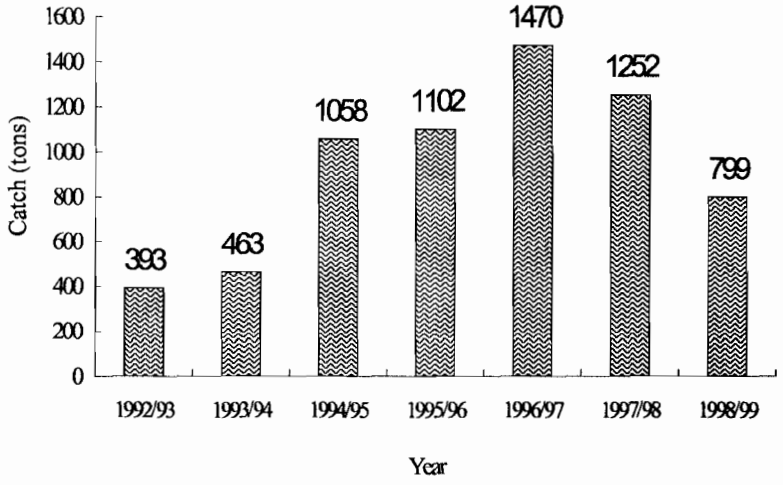

Fig. 2. Total annual catch estimates for Lake Tana including Gumara River.

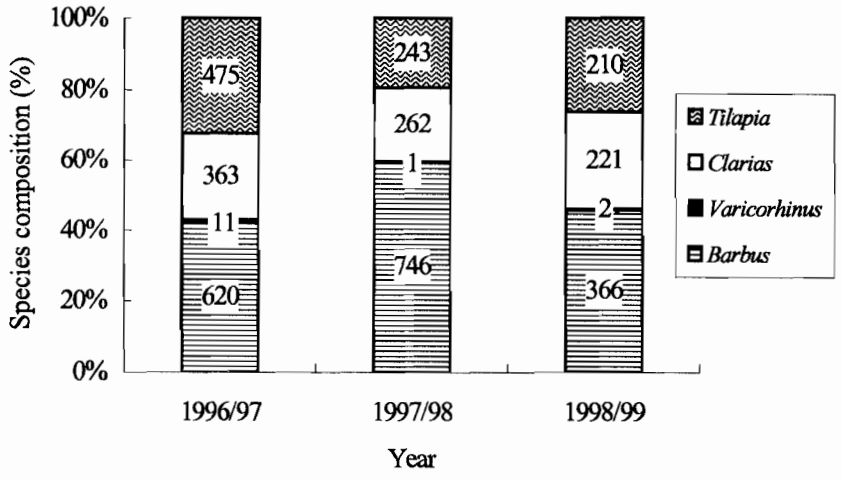

Fig. 3. Species composition of the total annual catch from Lake Tana, 1996/97 to 1998/99.

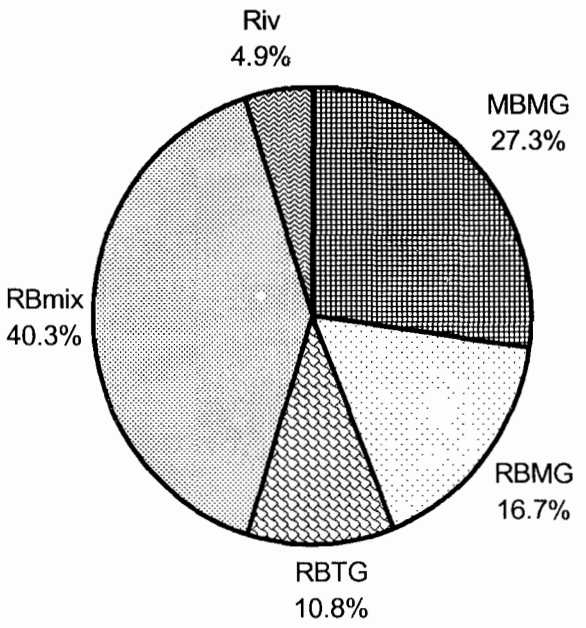

Fig. 4. Catch composition for Lake Tana by type of fishery (MBMG= modern boat with modern gillnet, RBMG= reed boat with modern gillnet, RBTG= reed boat with traditional gillnet, RBmix= reed boat with mixture of modern and traditional gillnets, Riv= riverine fishery with scoop nets, traps and hook and line).

This paper mainly deals with the evaluation of some fisheries biology parameters such as catch per unit effort, average size, total catch and effort, sex ratio and gonad maturity for the barbs of Gumara River. It tries to show the changes that occurred through time and explain the current status of the fisheries in the area. Based on the findings, we have proposed some management options to be applied for the protection and sustainable development of these fish resources.

MATERIALS AND METHODS

The data collection and analysis procedures followed are based on the principles discussed by Sparre and Venema (1992 a&b) and LFDP (1995; 1997). The commercial fishery data were collected from Gumara River at the entrance site to the nearest marketing rural town (Woreta) from 1993 to 1998. This comprises the ***total marketed riverine catch*** (whole fish) and the ***fishing gear*** used to catch these fish. It should be noted that considerable commercial

fishery is evident on Gumara River only during the main rainy season. Hence, the estimates were made using:

Total catch estimation (Gumara River) = daily recording of whole fish weight and number with the corresponding type and number of fishing gear used

This seasonal riverine commercial fishery data was also used to calculate the ***average size of an individual fish (barb) in weight*** on a weekly basis. Here the dividend of the total weekly catches (in weight) by the total weekly catches (in number) was computed. Although the data are recorded in kilograms, due to results having a value lower than unity, the unit of average weight is used to be in grams.

Average weight of a fish = catch (in weight) / catch (in numbers)

To see a picture of some major biological parameters (sex ratio and gonadal maturity) we also used exploratory gillnet fishery data (1995–1998) from Gumara River upstream (at Wanzaye) and at the river mouth (Megenagna). The materials used for data collection include gillnets, measuring boards, spring balances, the five-point maturity key that was discussed by Holden and Raitt (1979).

Stage I (Immature): *Ovary and testis about 1/3rd length of body cavity. Ovary pinkish translucent, testis whitish, ova not visible to naked eye.*

Stage II (Maturing virgin and recovering spent): *Ovary and testis about 1/2 length of body cavity. Ovary pinkish translucent, testis whitish, more or less symmetrical.*

Stage III (Ripening): *Ovary and testis about 2/3rd full length of body cavity. Ovary pinkish yellow with granular appearance, testis whitish creamy. No transparent or translucent ova visible.*

Stage IV (Ripe): *Ovary and testis from 2/3rd to full length of body cavity. Ovary orange pink in colour with conspicuous superficial blood vessels, large transparent ova visible. Testis whitish creamy, soft.*

Stage V (Spent): *Ovary and testis shrunken to about 1/2 length of body cavity. Walls loose, ovary may contain remnants of disintegrating ova, and ripe ova darkened or translucent. Testis blood shot and flabby.*

To make exploratory fishery data analysis we used PASGEAR ver. 01.12.98 (a data base package for experimental or artisanal fishery data from passive gears), which was developed by Kolding (1998). Standardized CpUE for gillnets, gonadal maturity and especially the riverine catch composition [Index of Relative Importance, (IRI)] results are processed with this database

package. IRI combines and shows, simultaneously, the relative numeric abundance (N), the average size (W) and the commonness (F) of a species; IRI=(%N+%W) * %F. The percentage [% IRI] gives the relative area of this rectangle in percentage to all other species present. For commercial fishery data analyses we used MS-EXCEL spreadsheet.

Additional references were made to the works done by the Lake Tana fisheries staff (under the Bureau of Agriculture), that is, the estimation of total annual catch from Lake Tana. We first made total effort and total catch estimates for every landing site and type of fishery on a monthly basis; then we summed up the results to estimate the total annual catch and effort for the lake. It is only gillnet fishery that is exercised on the lake although there are differences in the types of nets (traditional, modern and mixture of the two) and boats (reed, modern) used. We made records of samples of catch and effort data every month from the major landing sites on systematically selected sampling dates. When it was difficult to make real records of CpUE data (for some months and/or landing sites) we extrapolated the data from the nearest landing site (with the same type of fishery) or (the average of) adjacent months.

To estimate ***total effort***, we used measures of the number of nets used by a fisherman (or boat) per fishing day and the average number of fishing days by a fisherman (or boat) per month. The total effort unit used here is net-days.

Total effort (Lake Tana) = product of average number of nets used per day and average number of fishing days per month

To estimate ***catch per unit effort (CpUE) for gillnets***, the total sample weight (in kg) and the number of nets used to catch the sample were considered. The CpUE unit used here is kg per gillnet-day.

CpUE (for gillnets) = total sample weight / total number of gillnets used

To estimate ***total catch***, we calculated the product of total effort and CpUE. The unit of total catch was kg per month, which later on was converted into tons per year.

Total catch (Lake Tana) = CpUE * Total effort

RESULTS

Census on total fishing effort (Gumara River)

A fisheries baseline survey conducted along the northern (Fogera Woreda) side of Gumara River (including its mouth) in 1998 shows the presence of an enormous fishing effort in the area (unpublished data). The total number of fishermen living along the riverside and fishing directly on the river was found to be 312 (with 756 dependents). These fishermen possessed a total number of 159 scoop nets (all upstream), 52 fish traps (40 of them downstream), 130 hook and lines (140 mm shank length and 30 mm gap width). We found only two very small locally made gillnets very far upstream, and a single cast net was recorded somewhere. The lake fishermen who permanently reside just near Gumara River mouth numbered up to 17 (with 50 dependents), having a mixture of 20 modern and traditional gillnets used with 9 papyrus rafts.

The catches

Based on field observations and interviews we made at the fishing grounds, the fishermen used only about 25% of the total riverine catch for their own consumption (or was not marketed). This simply means that they took the bulk of the catch to the markets of the nearby rural towns and villages: Woreta, Hamusit, Anbessame and Jigna.

The barbs dominate the composition of the catch from Gumara River (about 90%). They constitute only about 50% of the total catch from Lake Tana and River Gumara (Figs 3 and 5). The catch composition results from the riverine gillnet exploratory fishery program conducted upstream (at *Wanzaye*) throughout the year also indicated that the barbs cover about 92.5% by number, 88.9% by weight [with frequency of occurrence (%F) of 98.6 and Index of Relative Importance (IRI) of 96.9%] (Table 1).

The total marketed rainy season catch (Woreta town) from 1992 to 1998 shows a clear picture of the decline in the riverine barb catch (Fig. 7). The increase until 1994 was due to the increase in the fishing effort (no. of fishermen, scoop nets and fish traps). From 1995 onwards it was impossible to have a catch equal to one-third of the 1994 peak (19.0 tons). The total annual catch records from Lake Tana also indicated an increase until 1996/97 and a decline then after (Fig. 2).

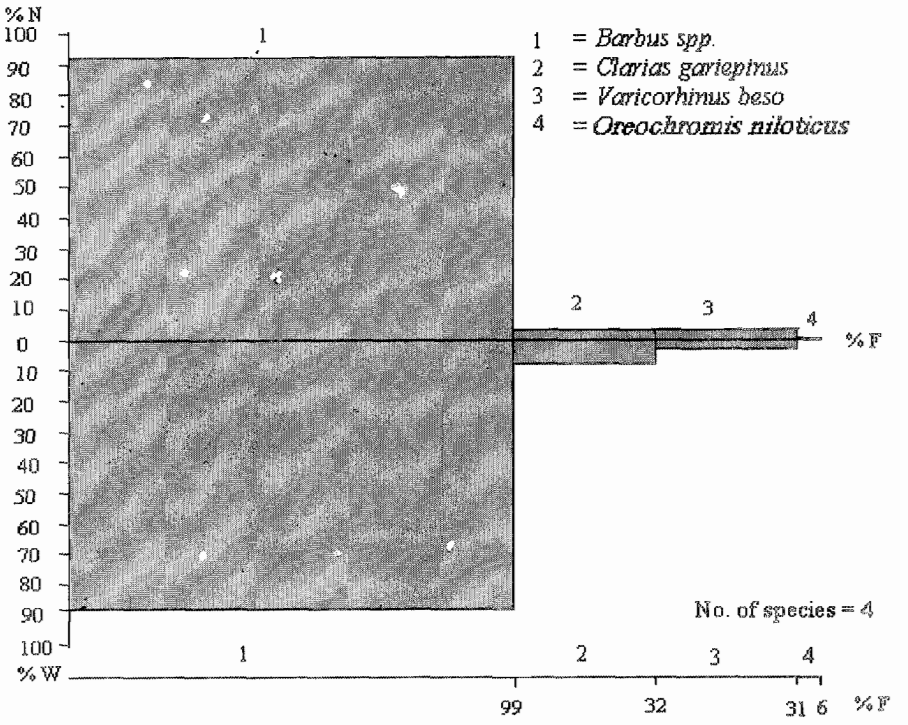

Fig. 5. Catch composition for Gumara River by species with IRI.

Table 1. Species composition of the gillnet exploratory fishery catches from Gumara River at Wanzaye (upstream) by species with IRI.

SPECIES	Catch composition by species							
	No	%	Weight	%	Freq	%	IRI	%
Barbus spp.	1948	92.5	946.8	88.9	143	98.6	17887	96.9
Clarias gariepinus	77	3.7	82.4	7.7	46	31.7	361	2.0
Varicorhinus beso	73	3.5	33.5	3.1	45	31.0	205	1.1
Oreochromis niloticus	8	0.4	2.7	0.3	8	5.5	3	0.0
Sum	2106	100	1065.3	100			19457	100

CpUE and average size

The exploratory fishery program using gillnets (70, 80, 90, 100, 110, 120 and 130 mm mesh sizes) conducted on Gumara River from 1995 to 1998 has enabled to deduce some important facts about the barbs. The standardized CpUE is one of the most important results that enable to say something about the migratory condition of these fish. The monthly CpUE estimates made by merging all mesh sizes and pooling all years were on average about 18 fish/setting/month for the dry season and about 48 fish/setting/month for the rainy season (Fig. 8). This reconfirms earlier ideas on the existence of spawning migration of Lake Tana's big barbs upstream to the rivers during the rainy season (July to September) (Nagelkerke *et al.*, 1995b). This is well supported by the fact that the low water level of the rivers, which in some places leaves the pebbles exposed above the water level during the dry seasons, does not allow easy movement of the fish upstream. But there is no clear indication of the year to year gillnet CpUE trend as continuous monthly sampling with all the mesh sizes was impossible due to high water level upstream on Gumara River and to some other logistic problems.

Rather we tried to relate the CpUE trends for the most commonly used traditional riverine fishing gear (scoop nets, fish traps and hook and line) with results of average size (in weight) of an individual fish from the commercial catches. Mean rainy season CpUE estimates (effort not standardized) made from 1995 to 1998 resulted in an increase on average from about 12 fish/gear/day to about 23 fish/gear/day (Fig. 9). This increase of CpUE in numbers within a period of three years is explained in the 'Discussions' part together with the average size result (the most clear and important indicator of the status of the barbs). In general, we found that the efficiency of scoop nets to catch fish on Gumara River was almost 1.5 times more than fish traps and almost 3 times more than hook and lines.

The average size of a marketed barb from Gumara River was about 923 g in 1995, 613 g in 1996, 604 g in 1997 and 481 g in 1998, showing a decrease by about half within three years period (Fig. 10). The weekly fluctuation of average size results with the same pattern repeated from year to year will be discussed later on in this paper.

Sex ratio and gonadal maturity

Out of most of the barbs examined for sex ratio during the four years gillnet exploratory fishery program on Gumara River (5218 specimens,) about 53.3% were found to be females. Of the female fish caught upstream at Wanzaye throughout the year, 75 to 100% were mature (ripe and spent) (Fig. 6-A). These results show that both sexes migrate to the river for spawning.

DISCUSSION

As the results of the fisheries baseline survey and the total fishing effort seasonally engaged on Gumara River show, a highly destructive fishing effort is operating in the area. The effort increased from year to year resulting first in a shooting up and then a sharp collapse of the catch. It is also clear that it was the scoop nets that were the most efficient gear used for fishing upstream.

Gumara River contributes about 5% to the total annual catch of Lake Tana and hence seems to have little importance (Fig. 4). But it demonstrates the reverse when considering the maturity stages of these riverine barbs (with 50–100% ripe fish at different times of the year) (Fig. 6 A and B). We can imagine the extent of the loss that would result from extensively fishing on exclusively ripe fish, of which the females (more than 50%) could spawn tens or hundreds of thousands of eggs in one breeding season.

Considering Lake Tana's total annual catch trend, the 1996/97 peak (1470 tons) was, as some experts in the Regional Bureau of Agriculture say, reached due to year to year input of additional fishing effort (modern gillnets and motorized boats) by the credit program of the EU/MoA funded Lake Fisheries Development Project (LFDP) and another smaller project. However, as is shown in Fig. 4, it should be noted that the highest contribution (about 75%) to the total annual catch comes not from the motorized boats, but the reed boat and riverine fishery to which the credit program practically had little or no contribution. This does not mean the modernization of the fishery did not contribute at all to the lake's annual catch. Rather it would be reasonable to say that the catch and effort data collected before LFDP's operation 1) may not have included partially (or at all) the reed boats and rivers which are highly distributed outside the southern part of the lake (LFDP, 1997). 2) even if the other bigger portion of the lake was included, the estimates could not be that much reliable as there was no responsible fisheries staff assigned to the lake-bordering Woredas of North and South Gondar. The decline in the following years could possibly have happened due to the high removal of spawner barbs from the rivers during the previous years (there was no indication of a decrease in the total fishing effort on the lake).

However, the CpUE (number of fish caught per riverine gear per day) trend as a function of time did not show a decline (Fig. 9). Rather it resulted in a slight (for trap and hook and line) to considerable (for scoop net) increase within three years. This is a case that could not actually happen in fisheries when total fishing effort is increasing. Normally it is expected that with increasing fishing effort, and consequently removing some fish from the

stock, CpUE should decrease. In our case, during the period 1995 to 1998 the number of scoop nets and hook and line used to catch the marketed fish was increasing (Table 2). This means we expect a decline in CpUE (in numbers). The best possible explanation for the increase in CpUE is that especially scoop nets, which have higher fishing power and are used in larger numbers than traps and hook and lines, are active gear (gear that are moved towards the fish for a relatively shorter period of time with repetitions). And hence the fishermen who were having better catches (big and many fish) within a short period of time at the earlier years increased the fishing hours to compensate for the poor catches (small and few fish) at the later years. Considering total effort as an indirect measure of CpUE leads us to the fact that, with increasing total effort (and decreasing total catch) the actual standardized CpUE has decreased as a function of time.

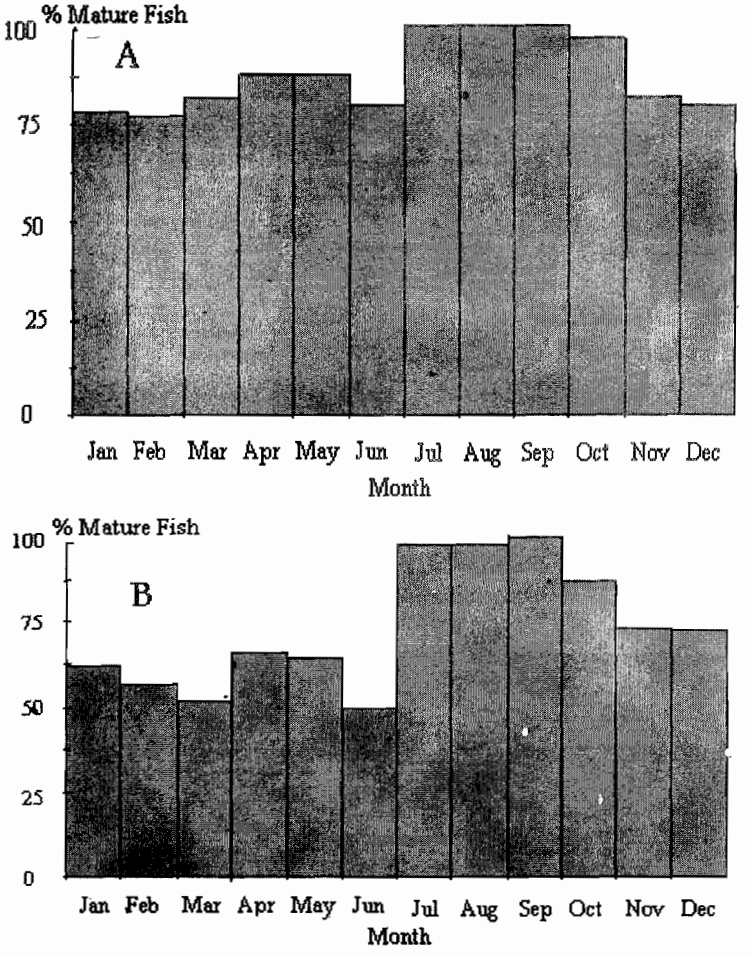

Fig. 6. Percentage of reproductively mature barbs (stages 4 and 5) upstream (at Wanzaye) on Gumara River [A= females (n = 1395), B= males (n = 853)] [all years pooled].

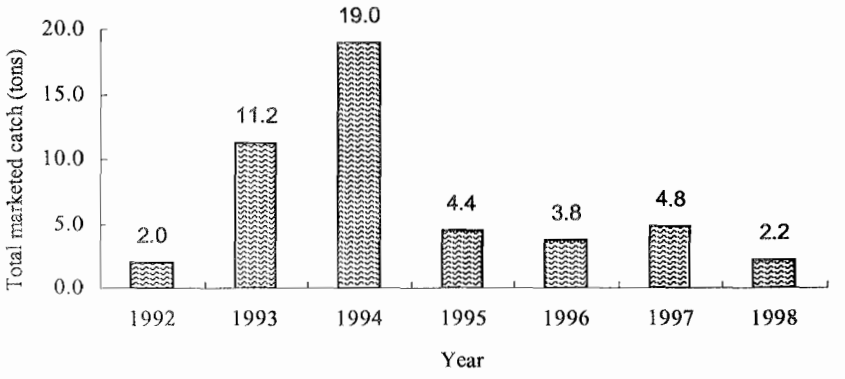

Fig. 7. Total marketed rainy season barb catch records from Gumara River, made at Woreta town.

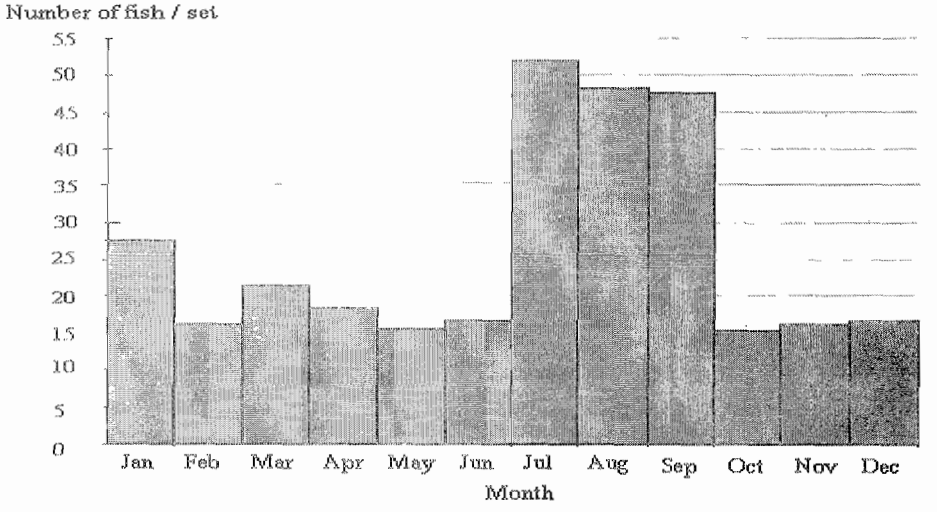

Fig. 8. Mean standardized barb catch per unit of effort (in numbers/set) by month for gillnets (100m length, 3m depth, and mesh sizes of 70, 80, 90, 100, 110, 120 and 130mm), exploratory fishery data of all years pooled.

The average size for the marketed individual fish decreased from year to year due to preference for large fish size by fishermen and their customers. The scarcity of the large fish consequently led to the removal of the smaller ones with no selection made for the different types of barbs.

Catch per unit effort is directly proportional to the amount of fish present. The trends in CpUE (in numbers of fish) and mean size provide very useful insights into what is happening with the stock. As is explained by LFDP (1997) when both CpUE and mean size of the fish decrease through time

(years), it is a bad condition for the stock as well as for the fishermen. The fishermen themselves also complain about the scarcity of fish in recent times although they did not try to implement some kind of their own indigenous control mechanism beyond seeking governmental support.

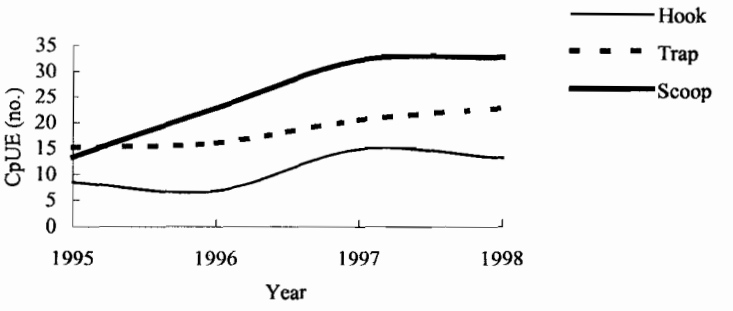

Fig. 9. Mean annual rainy season catch per unit of effort (in numbers) for the commercial fishery in Gumara River.

Table 2. Total fishing effort (in number of gear) used to catch the marketed fish (at Woreta town) from Gumara River during the main rainy season.

Year	Scoop net	Trap	Hook and line
1993	389	26	12
1994	516	84	131
1995	169	95	106
1996	204	88	49
1997	409	51	50
1998	700	73	119

Much more can be said by considering and relating different parameters recorded during the monitoring of the commercial fisheries and the exploratory fishery program. For instance, although it is beyond the scope of this paper, the mean size result shown in Fig. 10 also demonstrates some kind of regular pattern with similar ups and downs (every week) repeated from year to year. This is, as we expect it to be, an indicator of the sequentially designed spawning migration behaviour (one following after the other) of the different barbs. Even if the values for the mean size decreased, the pattern did not change from year to year. At least one idea can be suggested for sure: the patterns for the last week of the rainy season ends up in a smaller value every year. This means it is the week where 'Short-head barb', which has relatively the smallest adult size of all Lake Tana's large barbs, is highly abundant. Hence we can assume that 'Short-head barb' is the last of all barbs to migrate upstream (at the end of the rainy season), a case well supported by personal observations as well as fishermen's knowledge.

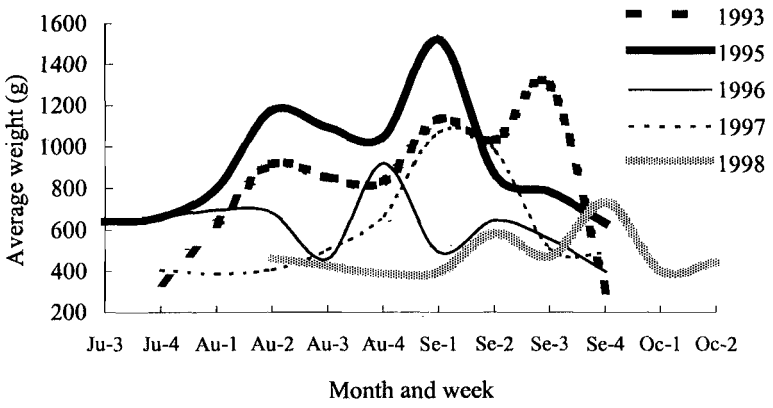

Fig. 10. Mean size of an individual marketed barb plotted for the months (letters) and weeks (numbers) in the rainy season, Gumara River.

Experiences in other parts of the world show that it is not easy task to implement the most important question of the day: harmonizing sustainable development (production) and conservation of natural resources. Here exists a gap between the two groups who directly watch the fish at close quarters. That is, based on the technical advises given and recommendations forwarded by fisheries experts, fish biologists, biodiversity promoters and researchers, it is time for policy makers and other concerned bodies at all administrative levels to take action. It is these bodies that could actually fill the gap. We have recently witnessed a remarkable model work done by Fogera and Dera Woredas of South Gondar in implementing a controlling mechanism for the dangerous fishing techniques exercised on Gumara River. Extension (inclusive of collection of data from the commercial fishery) and control are largely mutually excluding activities (LFDP, 1998) and preventive measures must be initiated now (Nagelkerke *et al.*, 1995b). Any fishery expansion has to be coupled with or preceded by fishery legislation and management regulation (Tesfaye Wudneh, 1998).

CONCLUSION

We strongly believe that there has to be some kind of controlling (management) measure to be implemented on the fisheries of Gumara River as it has been suggested in LFDP (1996). Here we also need to be very careful in that the fishermen in this area are new to fisheries management practices and we should not tell them about the decisions made as a surprise. We suggest step-by-step implementation of the management program: first disclosing the findings on the status of the fisheries and making thorough discussions with the fisher community is necessary. Then introducing

closure of fishing areas has to be considered together with gear restrictions (FAO, 1993). That is, during the whole main rainy season (July to September),

1) the motorized gillnet fishery operating on Gumara River mouth has to be stopped, and

2) the traditional fishing that uses various techniques (scoop nets, traps, cast nets, gill nets, and poisoning) also has to be fully stopped EXCEPT hook and line that could suffice for the fishermen's own consumption, but not dangerous to the stock. This management option may be applied until CpUE for the scoop nets and average size of the barbs on Gumara River shows considerable improvement.

Moreover, intensive fishing on spawner barbs alone may not be the sole cause for the decline in the harvest. The effect of the widely spreading and frequent use of the chemical DDT around Lake Tana's malaria susceptible catchment area is also not well studied. Herbicides and other chemicals used for "agricultural development" and other uses are no exception. At least the impacts of deforestation along riversides (e.g., Gumara and Reb Rivers in South Gondar), which led to soil erosion, formation of about 5 km of newly inundated peninsula in Lake Tana and diversion of the rivers' earlier routes are clearly evident at recent times. This by itself could be a cause for destruction of favourable spawning and nursery grounds. Ethiopia's freshwater fish fauna needs great attention (Abebe Getahun and Stiassny, 1998). The lake ecosystem consists of the lake and its drainage basin. Only when disaster is eminent, when risk of survival of a large population group is glaringly obvious to the majority, does a unified global response occur to save man from himself (Wetzel, 1983). The combined impact of man-made and natural environmental hazards will inevitably be magnified if we cannot act in time.

The only focus researchers currently made only on Gumara River and the Bahir Dar area of Lake Tana has to be widely applied to the other parts of the lake and its rivers. Also as Witte and van Densen (1995) put it, processing of data and reporting is one of the six major points involved in a fisheries monitoring program conducted by a fisheries research institute. The lake's fish stock assessment need to be conducted in a well-organized manner by assigning trained and skilled staff and retaining the existing experts, frequent field visits and progressive evaluation of work plans, allocation of the required budget and supplying research equipment, and disclosing findings to the international community. It is then that we could confidently talk about rational exploitation of our fish resources, otherwise the fate of Lake Tana barbs will be to live not in the water, but only in science books and films.

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